

Summary of Outcomes of 2018 Smart Building Roundtable Workshop

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Workshop Participants

Organizers

- Eliot Crowe, Lawrence Berkeley National Laboratory (facilitator)
- Hannah Kramer, Lawrence Berkeley National Laboratory
- Claire Curtin, Lawrence Berkeley National Laboratory
- Guanjing Lin, Lawrence Berkeley National Laboratory
- Michael Myer, Pacific Northwest National Laboratory
- Felipe Leon, Pacific Northwest National Laboratory
- Rois Langner, National Renewable Energy Laboratory
- Amy Jiron, U.S. Department of Energy
- Cindy Zhu, U.S. Department of Energy
- Marina Sofos, U.S. Department of Energy

Participants

Name	Organization
Dionysios, "Dan" Anninos	Iron Mountain
James Becker	CBRE/Sprint
Christian Bigsby	GSK
Paul Butapetch	Westfield
Andrew Carter	Commonwealth of KY
Susan Corry	Univ of MD
Aaron Daly	Whole Foods Market
Johnathan Flaherty	Tishman Speyer
Michael Groppi	CBRE
Alex Jahn	Willdan
Robert King	Target
Martha Larson	Carleton College
Pat Lydon	Legacy Health
Chip Pierpont	U.S. General Services Administration

Name	Organization
Alex Polo	Costco
Cristian Popa	7-11
Doug Rath	Marriott
Katie Rossman	Uni of Iowa
Francisco Ruiz	Oracle
Becca Rushin	Jamestown
Cameron Scott	Salt Lake City
Kenny Seeton	California State University Dominguez Hills
Darrell Smith	Google
Eric Teicholz	IFMA
Joe Thomas	Loews
Jon Utech	Cleveland Clinic
Craig Wright	Aurora Public Schools

Background

In February 2018 Lawrence Berkeley National Laboratory (LBNL) invited leading organizations to join national laboratories and the U.S. Department of Energy (DOE) at the Smart Buildings Roundtable. The main goal of the full-day workshop, hosted and facilitated by LBNL, was to gather insights to inform smart buildings research that fully accounts for commercial building owners' goals, needs, and challenges. Toward that goal the Roundtable was structured to meet three key objectives:



Photo: Marilyn Chung/Berkeley Lab

- Understand what motivates commercial building owners to pursue smart building technology adoption;
- Understand how the commercial building sector envisions the usage and uptake of smart building technologies;
- Understand the challenges and barriers faced by owners when deploying current technologies.

Representatives from 25 organizations attended the event, from commercial real estate, higher education, K-12 schools, retail, healthcare, hospitality, grocery, and government sectors. In addition to LBNL and U.S. DOE the event was also supported by the Pacific Northwest National Laboratory (PNNL) and the National Renewable Energy Laboratory (NREL).

Smart Building Definition

There is no accepted definition of a “smart building,” and a pre-event survey of Roundtable attendees provided a diversity of characteristics that would be considered “smart” for current or future buildings, such as:

- | | |
|---|--|
| • Integrated/coordinated control | • Realtime analytics |
| • Occupant-centric controls | • Visualization of performance and comfort |
| • Adaptable | • DR / DER / grid integration |
| • Self-healing | • Interactive, fun working environment |
| • Improved productivity and space utilization | • Self-driving |
| | • Voice control |

Based on survey feedback these are the four common attributes used for a working definition of a smart building for the purpose of guiding discussions at the Roundtable:

- Combination of smart devices and systems;
- Analytics supports proactive operations & maintenance, and better decision-making;
- Software automatically adjusts systems to optimize performance;
- System performance balances energy savings, occupant comfort, safety, and security.

These defining attributes were considered aspirational; many advanced buildings do not possess all of these characteristics.

Roundtable Format

The Roundtable workshop was intended to maximize collaborative group discussion (See Appendix A for agenda). Brief introductory presentations by DOE and national labs were followed by a full day of whole-group discussion and more focused breakout groups. The topic of smart buildings is very broad and by its definition highly interconnected; to allow for deeper dive and to help organize Roundtable findings the main topic was broken down into these five sub-categories:

- Data Management;
- Data Analytics;
- Advanced Control Strategies;
- Smart Devices and Plug Loads;
- Cross-Cutting Issues.



Photo: Marilyn Chung/Berkeley Lab

Organization of breakout groups was led by national laboratory researchers and DOE technology managers. Attendees completed a brief pre-event survey to help organizers develop an agenda and discussion guides that took account of attendees' experiences and interests.

Summary of Findings

The Roundtable was packed with vibrant discussion across a broad range of topics. Attendees were excited to share successes from their ongoing work, and place significant value on the opportunity to learn from their peers. With regard to the Roundtable objectives the high level outcomes were:

- **Motivation:** Benefits of smart buildings extend beyond energy cost reduction, to include occupant comfort and productivity, equipment life and reliability. Water efficiency also featured strongly for some owners, along with managing renewables and storage;
- **Vision:** Roundtable attendees are engaged in deploying a very broad range of advanced technologies. In an environment of rapid innovation, and in the absence of formal standards, owners are moving forward organically and opportunistically rather than planning a path toward a defined end point specification. A common element, however, is a vision for a robust and secure data management backbone to support smart building initiatives.
- **Challenges and Barriers:** Choice overload and fear of obsolescence is a fundamental barrier being faced by all owners (hence the value placed on learning from Roundtable peers). Additional technical and organizational challenges are summarized in more detail below.

Despite having a strong focus on barriers and challenges the Roundtable highlighted the significant capabilities that have been developed by participating organizations, in terms of technical infrastructure and staffing.

Current Landscape of Smart Building Technologies

Based on pre-event survey responses and discussions at the Roundtable, leading organizations are already seeing success with a broad range of smart building technologies. Data analytics was a strong theme, with most organizations utilizing an energy information system¹ (EIS) and many deploying fault detection and diagnostics² (FDD) software.

One participant highlighted work they're doing to combine analytics, demand response, and battery storage to mitigate high electric peak demand costs. Based on a robust data management platform several participants talked of tracking resources beyond energy, including water management and in one case data-enabled smart trash collection. Two participants mentioned their work to optimize space utilization using occupancy data and custom software. For one participant the use of an energy dashboard to engage regional hotel staff in an energy-saving competition has grown into a global effort.



Photo: Marilyn Chung/Berkeley Lab

In many cases a data management and analytics platform is installed to help facility staff optimize building mechanical systems' energy consumption and is then found to be valuable for other applications; in one case an owner has installed vibration sensors on air handling units to gather data that will help in predicting maintenance needs.

Experiences shared by Roundtable attendees demonstrate the significant potential of smart building technologies (and the capabilities of these organizations to

manage highly complex and sometimes risky deployments). However, even the most advanced organizations face challenges in deploying smart building technologies at scale, and these challenges will be amplified for organizations with smaller operational teams and budgets. A significant portion of the Roundtable was devoted to understanding the challenges, barriers, and limitations when installing smart building technologies, and these are summarized in detail below.

Challenges, Barriers, and Limitations

Through facilitated group discussions and breakout group sessions Roundtable organizers documented a wide range of challenges, barriers, and limitations relating to smart building technologies. In some cases, owners had overcome challenges but with frustrations and excessive time/effort/cost. Some challenges were technical, and some were organizational or general business-related issues. The key challenges, barriers, and limitations are summarized below, using the same five headings as used for the Roundtable breakout groups.

¹ An energy information system (EIS) is a combination of software, data acquisition, and communication systems used to store, analyze, and display building energy meter data on an hourly or more frequent basis. EIS is one type of energy management and information system.

² Fault Detection and Diagnostic (FDD) software identifies buildings with suboptimal performance by analyzing building automation system (BAS) data. FDD is one type of energy management and information system.

Data Management

Data is a fundamental element of all smart building efforts. The volume of data being collected in support of building operations management has grown exponentially in recent years. In many cases data is being transferred across multiple software and storage platforms, both on-premise and to/from cloud-based infrastructure. Some Roundtable attendees are managing hundreds of thousands of building automation system points across a portfolio of buildings, alongside thousands of meters. Two attendees described how their FDD software interfaces with their work order system (itself a very data-rich platform). Monitoring water consumption and other non-energy data sources was also cited by multiple Roundtable attendees. Attendees saw good data management as the foundation of their smart building technologies, and often data management became an initial obstacle to making progress. Key challenges, barriers, and limitations relating to data management are highlighted below.



Photo: Marilyn Chung/Berkeley Lab

Legacy Systems Integration

Any building portfolio is likely to have a mix of building vintage, control systems, system design, etc. that evolves over time. This complexity is compounded by inconsistent naming of data points and system components within building automation systems. Pulling data into a unified platform to perform organization-wide analytics is highly challenging: different systems have different means of communicating data, different output data formats, etc. Beyond point tagging there is also a need for analytics tools to understand the overall structure of building systems and the relationships between different system components (referred to as the “metadata” that describes these relationships³). The successes cited by Roundtable attendees (for example, one attendee described using machine learning to help with data tagging) demonstrates that legacy system integration problems are solvable, but it remains an area where significant effort and cost is incurred for outcomes (i.e. having data in a central platform) that do not directly improve building performance. Data overwhelm is a related issue; an owner needs to decide what data points are of most value, and what data frequency is appropriate. For all points that are imported to a central data warehouse there will be a need to confirm the data is accurate and to monitor for problems with connectivity or calibration. This effort to ‘commission’ the data management structure requires significant staff time, and it can take years to work through a large portfolio of buildings.

Data Security

Cybersecurity is of critical importance across all facets of a modern organization. Many smart building technologies require data to be transferred to internet-hosted analytics software, and although less common, some applications may even ‘push’ control signals from the internet to building systems. Unauthorized access to building systems’ data in the cloud may be a limited risk, but the greater concern is that an internet-hosted platform may provide a path through an organization’s firewall, thereby

³ Haystack and Brick are two examples of emerging metadata schema that are growing in popularity

allowing a hacker to access far more sensitive information throughout an organization (there are also concerns with other data communication protocols such as ZigBee and Bluetooth). Similar to dealing with legacy systems' data, cybersecurity protocols⁴ exist, but this is an additional layer of effort and risk for facility managers to address, and requires new working relationships to be established between IT and facility management.

Data Privacy

Occupant-centered building operations implies offering optimal comfort, light, and indoor environmental quality for occupants; occupancy-related data is a key input for this. Occupancy sensors are becoming more common, but most commonly provide only a binary occupied/unoccupied reading; measuring CO₂ levels may also be used as a proxy for occupancy. Several roundtable attendees expressed interest in getting better data on occupant density and the movement of people between spaces, for example by tracking Wi-Fi login statistics, volume of Wi-Fi traffic, or perhaps interfacing with building security systems where card access is required to enter spaces. While this data may be beneficial for developing more sophisticated control and analytics strategies there are understandable concerns about sharing this kind of personal information on individuals' locations. These concerns are magnified for the commercial real estate sector, where an owner's access to occupant or other operational data within tenant spaces is even more difficult or impossible to obtain.



Photo: Marilyn Chung/Berkeley Lab

Data Analytics

Data analysis and visualization is at the heart of energy management and information systems (EMIS) and other smart building technologies. Most Roundtable attendees were deploying EIS, FDD, or both; five attendees had been recognized for their EMIS success through the Smart Energy Analytics Campaign⁵. Key challenges, barriers, and limitations relating to data analytics and visualization are highlighted below.

Capturing Non-Energy Benefits

The majority of smart building investments are intended to reap energy cost savings, and several attendees described parallel efforts to reduce water consumption. Beyond those direct impacts Roundtable attendees believed that smart building operations can improve occupant productivity, reduce maintenance costs, extend equipment life, and some research has indicated a link with higher property values. One attendee noted the “3-30-300” concept, which provides a relative breakdown of what an organization pays per square foot, in terms of total occupancy costs: \$3 for utilities, \$30 for rent

⁴ ISO 27000 family of standards relates to information security, and was suggested by one attendee as a useful resource to look into. The U.S. General Services Administration has developed cybersecurity guidance at: <https://www.gsa.gov/technology/government-it-initiatives/cybersecurity>

⁵ EMIS success stories from the Smart Energy Analytics Campaign available at: <https://smart-energy-analytics.org/success-stories>

and \$300 for their employee costs (salaries, benefits, etc.). These numbers aren't set in stone but they put into perspective how non-energy benefits of smart buildings can have significantly greater benefits beyond direct energy cost savings. These non-energy co-benefits prove very difficult to quantify however, making some smart building investments even harder to justify (especially in regions with lower utility rates); analytics offerings do not yet capture and quantify non-energy benefits, and in general there is little direction for owners on how to monetize them.

Translating Insights into Action

Many roundtable attendees were users of EIS and FDD technology. These technologies provide insight into operational savings opportunities, but require proactive interventions to resolve identified problems. Some users cited challenges in finding facility staff with the skills for reviewing & managing analytics software. Others found it challenging to carve out staff time or make dedicated new hires to manage the EMIS efforts (this ties in with the general challenge of fully capturing smart building benefits



Photo: Marilyn Chung/Berkeley Lab

in order to justify investments). A recent LBNL report on FDD tools noted that decision makers must buy in to an increase in operation and maintenance expenses and be willing to manage a certain degree of risk. Translation of information into action requires allocation of resources for staff time and training to act upon identified fixes; it also requires effective operational response processes⁶. A related issue was lack of consistency and best practices around dashboard design and effective workflow for reviewing charts/reports and acting accordingly; this is more of a challenge in the case of EIS than with FDD where the analytics outputs are easier to

convert into actionable recommendations. Some owners are seeing success integrating FDD with work order software (also known as computerized maintenance management systems, or CMMS). Several attendees noted that the volume of data can be overwhelming, even with user friendly software that organizes and prioritizes analytics insights.

Energy Modeling and M&V Underutilized

Since advanced EIS tools started emerging almost a decade ago one commonly cited benefit was the ability to use smart meter data to create energy models to support granular measurement & verification and detection of energy consumption anomalies. Feedback from Roundtable attendees (reinforced through experiences with the Smart Energy Analytics Campaign) indicates that energy modeling functionality of EIS is underutilized. A related issue is that while EIS can estimate energy cost savings over time (an attractive feature for owners), these savings are typically calculated using a blended average utility rate, whereas the reality for owners is that their energy costs can vary significantly based on time of day/week/year and with very high peak demand charges in some regions. One Roundtable attendee cautioned that, if using energy models as a tool to maintain building performance it is important to optimize the building first (through existing building commissioning, for example), otherwise you will merely be using the data to maintain sub-optimal energy performance.

⁶ Granderson, Jessica, et al. *Characterization and Survey of Automated Fault Detection and Diagnostic Tools*. Berkeley: Lawrence Berkeley National Laboratory, 2017.

Patchwork Approach

Among Roundtable participants there was a diversity of analytics configurations. Some owners engage with a single vendor or service provider for a single turnkey analytics platform; Some utilize internal programming expertise to develop their own analytics and visualization platform; some will overlay platforms, for example using proprietary meter data management software to feed into FDD software, or pulling from an FDD data repository into an EIS dashboard. A key benefit of such a ‘patchwork’ approach is the ability to evolve analytics approaches over time and to select the best tools for a given need (for example, no tool currently combines best-in-class EIS and FDD in a single tool). The complexity of multiple interconnected applications makes it challenging to develop organizational procedures that integrate these technologies into operational practices; dealing with complexity is particularly challenging for organizations with smaller operations teams. This challenge is exacerbated by the fact that every building is unique.

Advanced Control Strategies

Roundtable participants typically utilize digital HVAC controls with separate lighting control systems, implementing control strategies common to commissioning and operational best practices (e.g. temperature or pressure resets, equipment lockouts, optimal start/stop). Some participants with smaller properties are using wireless thermostats and overlay control packages for rooftop HVAC units (RTUs). Smart irrigation controls were also mentioned as a significant energy saving strategy. Some advanced control strategies are generic whereas others might be sector-specific; one attendee from the healthcare sector noted significant benefits they achieved by monitoring the number of air exchanges in an operating theater so as to better match the control sequence to occupancy. Key challenges, barriers, and limitations relating to advanced control strategies are highlighted below.



Photo: Marilyn Chung/Berkeley Lab

Specifications & Complexity

The capabilities of digital HVAC control systems are well-documented, but owners often experience frustration that, as installed, they often fall short of optimal. Commissioning and ongoing analytics can rectify many controls-related issues but do not address the root causes. Lack of controls specifications, or insufficiently defined specifications, when engineers are communicating with vendors was cited as a common problem. Lack of standardization for advanced control sequences adds to the challenge of diagnosing control-related issues and refining sequences over time; ASHRAE Guideline 36⁷ is intended to improve consistency, though it will take time for the controls industry to shift away from established practices. As control sequences become more sophisticated the risk of programming errors increases, and there is an additional challenge in finding operators and service providers qualified to operate and maintain the controls.

⁷ Guideline 36 (in advanced phase of development) is titled High Performance Sequences of Operation for HVAC Systems. More information available at: <http://gpc36.ashraepcs.org/index.php>

Interoperability and Integration

Interoperability of controls was raised as an issue by several Roundtable attendees. For large portfolios with multiple control system types there is a need to pull data into a central repository and in some cases ‘push’ control changes out to individual building. Proprietary protocols can make this especially challenging. Beyond HVAC there is also a desire to see more integration with lighting, other end uses, and non-energy application (e.g. water). Also there is a disconnect between high level analytics (e.g. FDD) and adjustment of control sequences; closer integration of FDD and controls would help streamline issue resolution and continuous improvement of operations. FDD is not intended to automatically optimize controls; automated system optimization (ASO) tools exist, but only certain control aspects can be automatically optimized – some problems are physical issues in maintenance or design. Use of ASO tools was not mentioned by Roundtable attendees, and current adoption rates are believed to be low.



Photo: Marilyn Chung/Berkeley Lab

Smart Devices and Plug Loads

While the “internet of things” (IoT) and smart devices are currently popular buzzwords, they did not feature strongly in Roundtable discussions. Some attendees noted promising work installing lighting with embedded controllers, and ‘smart valves’ for built up HVAC systems are also in the early stage of adoption with some attendees. In general, there is a lack of clarity around the definition of IoT and what problems IoT technology aims to solve. Key challenges, barriers, and limitations relating to smart devices and plug loads are highlighted below.

Business Case and Ongoing Maintenance

Plug loads have been growing as a proportion of overall building consumption, largely due to successful efforts in reducing HVAC and lighting loads. Smart outlets and smart power strips target efficiency in plug load energy use, but given that individual loads are typically small it is hard to make the business case for organization-wide adoption (effort and hardware). And even in cases where an owner invests in plug load controllers and smart strips there is concern about the level of effort required to manage, track, and maintain hundreds (maybe thousands) of distributed devices, especially as plug loads may move between locations in a building over time. For leased properties these challenges can be affected by tenant agreements and how the utility costs are structured (the so-called ‘split incentive’ situation where neither owner nor tenant may be motivated to invest in reducing plug loads).

Interoperability and Cybersecurity

As with the topic of building controls and metering, data security is a major concern when considering IoT technologies. Cybersecurity concerns are amplified if dealing with hundreds/thousands of internet-connected devices, especially if they are provided by a variety of vendors. There are also concerns around interoperability of systems, potential for obsolescence, and how to manage firmware and software upgrades over time.

Cross-Cutting Issues

Organizations that embrace smart building technologies are faced with many new considerations that affect those involved in planning, implementing, and using the technology. Leading organizations are adding analytical skillsets to their operational teams and adopting data-rich approaches to decision-making. Instead of wondering “how can our operations staff review analytics software when they are already overburdened?” leading organizations are working out how analytics can be an integral part of directing and prioritizing the efforts of their operations team. Roundtable attendees described how their analytics software not only helps them optimize operations, it also enables them to more rigorously evaluate pilot installations of new technologies. This level of rigor provides greater confidence before widespread adoption of a new technology or, conversely, allows an owner to “fail quickly, fail small” and move on to other possibilities.

Choice overload and fear of obsolescence

The Smart Energy Analytics Campaign website lists 56 available EIS applications, 27 FDD tools, and 42 EMIS service provider firms – this is just a subset of the EMIS market, and EMIS is just one area of smart building technologies where an owner has choices to make! The range of options is daunting for owners, and there is very little consistency in feature sets and the way vendors describe their products’ functionality.

Once an owner has decided they want to implement smart building technologies it can be challenging to develop an RFP to suit their needs and budget, due to the complexity of offerings and limited industry guidance on developing procurement specifications. There is major concern not only in comparing products’ functionality but also in having confidence in the long term viability of software and vendors that, in some cases, didn’t even exist two years ago. Given the cost, effort, and level of integration of some smart building technologies it is difficult sometimes to ‘fail small.’ In some cases, a third party vendor can reduce an owner’s upfront investment (for example, offering cloud-based data warehousing), though this can mean they are locked in with that vendor and make it harder to switch in future. Roundtable attendees value the kind of peer-to-peer sharing accessible through the Roundtable and other industry groups, and also the kinds of technology demonstrations and case studies provided through national labs; attendees talked of having technology vendors “knocking on the door daily,” so objective sources of information are highly valued.



Photo: Marilyn Chung/Berkeley Lab

Demonstrating a Holistic Business Case

Making the business case for smart building technologies can be challenging as the benefits can be difficult or impossible to quantify upfront. Optimizing operations has been demonstrated to save 5-15% in energy costs (and in many cases 15%+), but it is not easy to predict savings or costs upfront for an

individual building or portfolio. Beyond direct utility cost savings, the benefits of smart buildings are manifold, but often very hard to quantify, such as:

- Maintenance savings/labor cost;
- Streamlined operational practices;
- Occupant comfort and productivity;
- Supporting data-driven decision-making;
- Enhanced property value;
- Safety;
- Environmental safety;
- Space use efficiency;
- Grid-responsiveness;
- Improved customer experience.

This challenge is compounded by the fact that some investments may have an immediate cost and related benefits but also lay the groundwork for future investments. This is particularly true when setting up data management and control infrastructure, which may have short-term impact of reducing energy costs by 10% but also enables future applications such as supporting water efficiency efforts or integrated management of onsite renewables and energy storage; the initial investment may not be justified on the short term savings alone., and the long term impact cannot be quantified

As is true in many aspects of energy efficiency, there is an additional split incentive barrier for investments in leased properties in many cases, whereby an owner may be reluctant to make investments in a property where a tenant is paying all energy costs. Another general issue is that, in most organizations, energy efficiency projects are competing with many other organizational priorities for funding. These were not cited as major barriers by Roundtable attendees but is still a known issue affecting many properties.

Facility Management / Information Technology Interface

A decade ago operations teams did not need to get too involved with IT; this is changing rapidly with the emergence of smart building technologies. In general building operators now understand the importance of collaborating with IT but the nature of that relationship is still relatively undefined and it takes time for staff in both disciplines to understand each other's needs. For example, one Roundtable attendee mentioned that enterprise-wide IT network updates in their organization unexpectedly interrupted EMIS data communications; neither IT nor the facilities team was aware of the risk in that situation. Another noted a case where diagnosis of EMIS communication issues were hindered by a lack of documentation around routing of Ethernet cables used for meter hardware connections.

Lack of Standardization

The last decade has seen a rapid expansion in smart building technology offerings, and building owners have successfully deployed them in a variety of situations. In the absence of technology standards and standards of performance for vendors and service providers the emphasis is on building owners to develop and enforce their own specifications which can require significant effort. Roundtable attendees noted that individual owners do not have enough buying power to shift industry practices toward higher quality installation of smart building technologies, and wondered if there could be a collaborative approach to setting requirements.

Engaging and Incentivizing Staff and Occupants

The impact of smart building technologies can be significantly affected by building staff and occupants (advanced controls may be over-ridden, analytics recommendations may be ignored, etc.). Facility staff may see advanced controls and analytics as a threat to their profession rather than a new tool at their disposal; having developed mechanical skills through their career it may be challenging for operators to adapt to advanced analytics/software driven approaches to operations management. Owners often cite challenges in recruiting staff with the necessary skillset to work with advanced technologies. Simple training materials, public dashboards, energy-saving competitions, reports of energy-related key-performance indicators, and incentive programs are all examples cited by Roundtable attendees to help engage staff and occupants. In spite some efforts to educate/engage occupants and operators it is typical that oversight of smart building technologies lies with a small central team of specialist facility management staff.

Conclusions

Significant progress is being made by leading building owners to deploy smart building technologies. With high level commitment (often backed up with written commitments toward greater sustainability), passionate internal champions, well-informed staff and service providers, organizations are able to



Photo: Marilyn Chung/Berkeley Lab

manage the risks around selecting and implementing analytics, advanced controls, and smart devices. Once owners have established a solid foundation for data management they are better able to measure and evaluate the impact of all smart building technologies. While smart building investments are often justified based on energy savings owners recognize many non-energy benefits including occupant comfort, maintenance, asset management, and here are related efforts to reduce water usage.

Even the most advanced building owners admit to challenges, however. After a decade of rapid innovation smart building technologies are in a ‘Wild West’ environment, where owners have a dizzying array of product options, many from vendors who didn’t exist a few years ago. This is a challenge not only in choosing technologies but also in having staff and service providers keep up with skills and training needs.

The Roundtable highlighted the significant potential of smart buildings, along with significant complexity faced by owners in specifying, selecting, and operating smart building technologies. Opportunities for research, technology, and best practices development were evident across all topics covered at the Roundtable, with a few high level themes emerging:

- To what degree can the analytics power of FDD be integrated with controls to enact automated system optimization?
- How can water efficiency and other non-energy benefits be monetized and integrated with smart building technology development?

- What degree of standardization and guidance is appropriate for smart building data management to balance the need for consistency with the need for innovation and meeting diverse owner needs?
- How can analytics support optimal balance of grid resources, demand response, renewables, and energy storage?
- How can control and ongoing management of plug loads, lighting, and HVAC be fully integrated?
- How can owners capitalize on the full energy modeling benefits of EIS for M&V and load shape management?

The enthusiasm of organizations who attended the Smart Buildings Roundtable is testament to their desire to share experiences and learn from their peers about best practices and products that are proving successful, and lessons learned from unsuccessful deployments. The lack of standardization in product offerings is a natural outcome of rapid innovation, but standardization will be necessary in some technology areas if smart building technologies are to expand beyond the most advanced owners. There is also the ongoing challenge to justify smart building investments when energy cost reductions alone are not sufficient to meet return-on-investment thresholds; non-energy benefits can dwarf the direct energy cost reductions, but have proved very difficult or impossible to quantify. By tackling the challenges identified during the roundtable through research and public-private partnerships, organizations can work together towards achieving smart buildings.

Appendix: Smart Building Roundtable Agenda

Date & Location: Tuesday Feb 6 – Lawrence Berkeley National Laboratory, Bldg 54, Pers Hall

8:30 Continental Breakfast

9:00 Safety presentation

9:05 Session 1

Session objectives: *Based on this session we will gain an understanding of:*

- *Breadth of smart building technologies being implemented/explored by attendee organizations*
- *Overall goals/objectives or organizational problems that are being addressed through these efforts*
- *Technology capabilities of most interest to attendees*
- **National Labs/DOE introduction presentation**
Brief overview of current smart buildings work being conducted by National Labs and DOE. Also, general information & background for the roundtable.
- **Attendee introductions**
- **What's going on? Whole group discussion**
Facilitated discussion including the overall objectives of organizations for using smart building technologies; learning about successes; why and who are driving these projects within organizations? Discussion focuses more on participant objectives and less on gathering a list of all the problems (focus of later session).

Morning break 10:30-10:50

10:50 Session 2

Session objectives: *Based on this session we will:*

- *Close out any remaining topics from the prior session*
- *Dive deeper into key topic areas, to understand the implementation issues being encountered (for those implementing technology)*
- **All group discussion** continues, covering any topics that didn't get covered before break
- **Breakout groups**

12:00 Lunch (onsite at LBNL)

1:00 Session 3

Session objectives: *Based on this session we will:*

- *Validate and refine the key themes identified in the morning sessions*
 - *Prioritize these themes*
 - *Refine the definitions of these themes*
- **Breakout groups report out**
- **'Roaming' exercise**
Attendees will walk around and use sticky notes to share independent thoughts, considerations, or challenges associated with the key themes identified during the breakout exercise.
- **Breakout groups re-convene and update findings**

2:45 Afternoon break

3:05 Session 4

Session objectives: *Based on this session we will:*

- *Finalize documenting key themes identified through the day*
 - *Share future collaboration plans*
 - *Provide concrete follow up actions*
- **Breakout groups report-out, & whole-group discussion**
 - Organizer take-aways**
National Labs and DOE attendees summarize outcomes and learnings from the day.
 - Future collaboration opportunities**
Discussion of opportunities for attendees to collaborate, and other upcoming events.

4:15 Roundtable ends

4:30-5:00 Optional Flexlab tour